2017-02-10

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http://hdl.handle.net/10026.1/9675

10.1002/ecs2.1688
Ecosphere
Wiley

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Assessing the ecological coherence of a marine protected area network in the Celtic Seas

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Citation: Foster, N. L., S. Rees, O. Langmead, C. Griffiths, J. Oates, and M. J. Attrill. 2017. Assessing the ecological coherence of a marine protected area network in the Celtic Seas. Ecosphere 8(2):e01688. 10.1002/ecs2.1688

Abstract. Marine protected areas (MPAs) are a management tool used to respond to human-derived threats in marine ecosystems. Historically, MPAs have been established on an individual ad hoc basis, rather than through a systematic, planned process. However, high levels of functional and spatial connectivity within marine ecosystems have led to the suggestion that networks of MPAs provide greater ecological benefits than individual MPAs. Consequently, international policy has developed to consider broader spatial requirements for marine conservation, resulting in a number of international and regional agreements that require the establishment of ecologically coherent MPA networks. Existing MPAs are now being considered, retrospectively, alongside new designations, as networks of MPAs across regions, both nationally and internationally. Under the Marine Strategy Framework Directive (MSFD), France, the Republic of Ireland, and the UK (including Northern Ireland and the Isle of Man) are required to work together to ensure coordinated development of marine strategies for the Celtic Seas subregion. Accordingly, MPAs have been identified as crucial components of the programme of measures to achieve Good Environmental Status (GES) under the MSFD. Here, we provide the first ecological coherence assessment of an MPA network spanning an MSFD subregion. A network of 533 MPAs, or parts thereof, across the Celtic Seas subregion was assessed using five criteria and two methodologies, with a focus on broadscale habitats. While the Celtic Seas MPA network as a whole is not ecologically coherent (according to accepted thresholds), progress toward a number of global targets has been achieved, for example, protection of 10% of marine and coastal areas under the Convention on Biological Diversity. Further, all MSFD predominant habitat types assessed are adequately represented and replicated within the network. However, a number of gaps were identified, including a lack of MPAs in offshore and deeper areas, and inadequate proportions of predominant habitat types within MPAs. Addressing these gaps to enable the MPA network to fulfill its critical role in the delivery of GES under the MSFD will require both national progress toward designation of adequate and viable MPAs and transboundary agreements and coordination of MPA designation processes at the European level.

Key words: biodiversity conservation; marine protected area; Marine Strategy Framework Directive; OSPAR; predominant habitat type.

Received 11 October 2016; revised 16 December 2016; accepted 19 December 2016. Corresponding Editor: Debra P. C. Peters.

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Introduction

Marine protected areas (MPAs) are a management tool used to respond to human-derived threats in marine and coastal ecosystems. The International Union for Conservation of Nature (IUCN) defines a MPA as "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve long-term conservation of nature with associated ecosystem services and cultural values" (Dudley 2008). By reducing local-scale stressors, MPAs can provide a number of benefits, including conservation of biodiversity and biomass, protection of habitats, increased resilience, and enhancement of ecosystem services (Lubchenco et al. 2003, Mumby and Harborne 2010, Edgar et al. 2014, Rees et al. 2014). Historically, MPAs have been established on an individual ad hoc basis, over varying timescales and with different conservation objectives, rather than through a systematic, planned process (UNEP-WCMC 2008, Toropova et al. 2010). However, the high level of functional and spatial connectivity within marine ecosystems (Natural Resource Council 2000, Agardy et al. 2003, 2011, Carr et al. 2003) has led to the suggestion that networks of MPAs provide greater ecological benefits over individual MPAs (Dudley 2008, UNEP-WCMC 2008, Johnson et al. 2014). In response to this, international policy has developed to consider broader spatial requirements for marine conservation, resulting in a number of international and regional agreements that now require the establishment of ecologically coherent MPA networks (European Commission 1992, 2008, UN 2002, OSPAR 2003, CBD 2004), which:

1. interact and support the wider environment (OSPAR 2006, Sects. 5.3, 6);
2. maintain the processes, functions, and structures of the intended protected features across their natural range (Laffoley et al. 2006);
3. function synergistically as a whole, such that the individual protected sites benefit from each other to achieve the above two objectives (based on OSPAR 2006, Sect. 5.2); and
4. may be designed to be resilient to changing conditions (OSPAR 2006, Sect. 5).

In 2010, contracting parties to the Convention on Biological Diversity (CBD) adopted Aichi biodiversity target 11 stating that, "by 2020, at least 17% of terrestrial and inland water, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes" (CBD 2010). As a consequence of these policy developments, existing MPAs are now being considered retrospectively, alongside new designations (such as Marine Conservation Zones in the UK arising from the 2009 Marine and Coastal Access Act; UK 2009), as networks of MPAs across national and international regions and at varying spatial scales. Furthermore, the European Union (EU) Marine Strategy Framework Directive (MSFD), which is central to the EU's Integrated Maritime Policy, requires EU Member States to reach or maintain Good Environmental Status (GES) in the marine environment by 2020. In particular, Article 13(4) stipulates that Member States need to include into their programmes of measures "spatial protection measures, contributing to coherent and representative networks of MPAs, adequately covering the diversity of the constituent ecosystems, such as special areas of conservation pursuant to the Habitats Directive, special protection areas pursuant to the Birds Directive, and MPAs as agreed by the Community or Member States concerned in the framework of international or regional agreements to which they are parties" (European Commission 2008). The MSFD requires GES to be reached across the marine environment as a whole, not just in areas bound by spatial protection measures. Thus, in order to work toward GES in a strategic manner, the MSFD has delineated four marine regions (the Baltic Sea, the North-East Atlantic Ocean, the Mediterranean Sea, and the Black Sea), which have been further divided into subregions. Member States are required to develop coherent and coordinated marine strategies in respect of each marine region or subregion. The North-East Atlantic Ocean is divided into four subregions, one of which is the Celtic Seas (Fig. 1).

Under the MSFD, France, the Republic of Ireland, and the UK (including Northern Ireland and

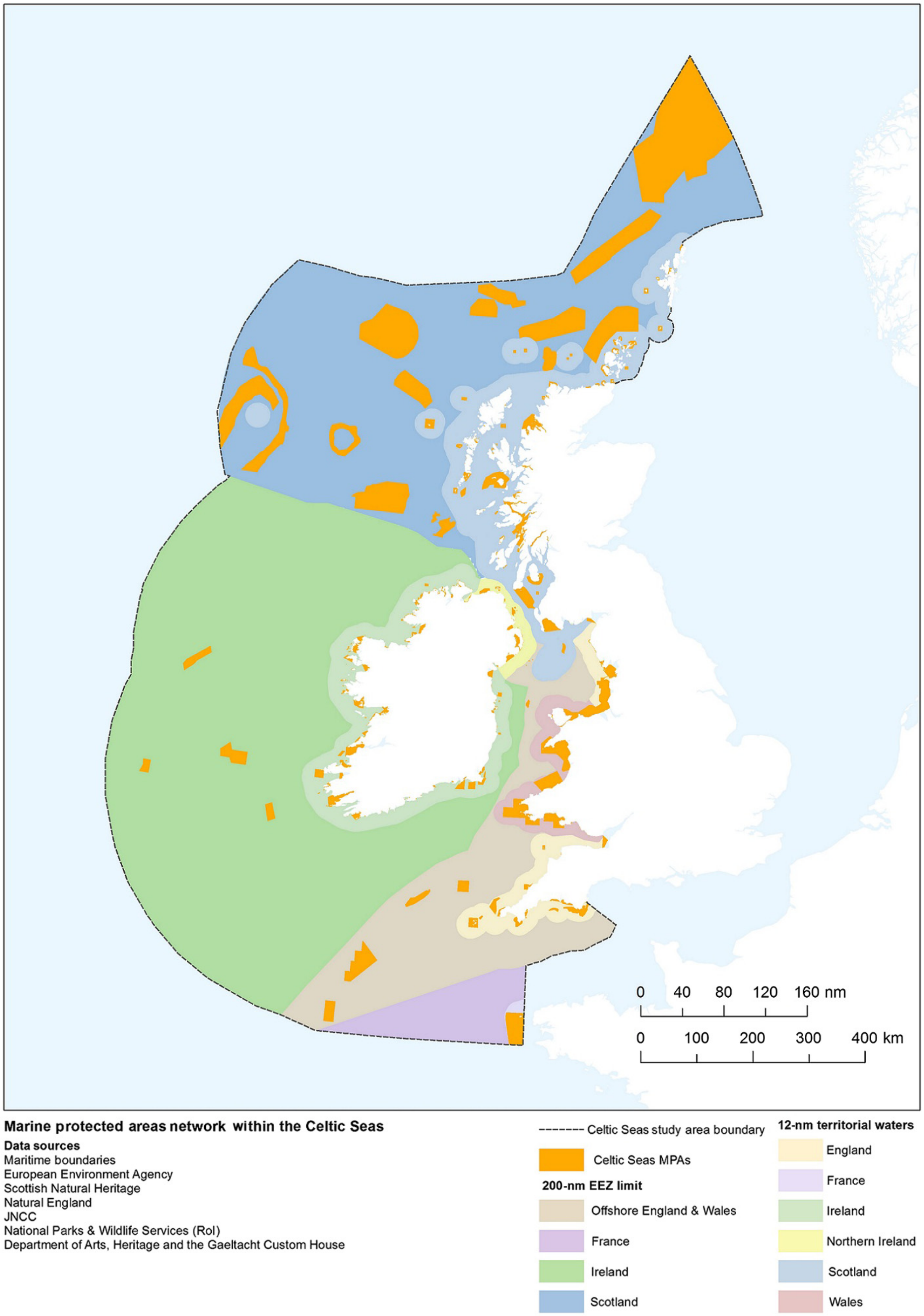

Fig. 1. Spatial distribution of the marine protected area network in the Celtic Seas MSFD subregion.

the Isle of Man) are required to work together to ensure coordinated development of marine strategies for the Celtic Seas subregion (Article 1 (13) of the MSFD). The steps required in this process include an initial assessment of the marine waters comprising the subregion, determining a set of characteristics for GES, establishing environmental targets and monitoring programs, and identifying the measures required in order to maintain or achieve GES (European Commission 2008), all of which require effective transboundary engagement from a number of partners. The Marine Strategy Part Three: UK Programme of Measures (Defra 2015*b*) refers heavily to existing MPAs as being crucial components of the programme of measures to achieve GES, and in particular for achieving targets set within Descriptor 1 (biodiversity) and Descriptor 6 (seafloor integrity). Ireland's programme of measures public consultation document (DECLG 2015) also refers to the role of MPAs in supporting the achievement of a number of GES targets, in particular for Descriptor 1 and Descriptor 6. In addition, the French government's consultation on the programme of measures in the Celtic Seas marine subregion (MEDDE 2014) mentions the contribution of MPAs toward the MSFD and includes provision for new measures to extend and improve the network of MPAs and to make them more coherent via existing regulatory tools. Thus, assessing the current status of existing MPAs to form an ecologically coherent network is a logical important step in developing marine strategies for the Celtic Seas subregion. The Celtic Seas Partnership, an EC Life+-funded project led by WWF-UK, was set up to support implementation of the MSFD in the Celtic Seas, using a stakeholder-led approach. WWF-UK commissioned the current study to assess the ecological coherence of the existing MPAs within the Celtic Seas subregion, to support the Celtic Seas Partnership. While ecological coherence assessments have been undertaken previously at varying spatial scales, none has been conducted at the MSFD regional or subregional level. Here, we provide the first ecological coherence assessment of a network of MPAs spanning an MSFD subregion.

In order to determine whether existing MPAs form ecologically coherent networks, and to assess the suitability of these networks to meet conservation objectives, a number of criteria (representativity, replication, adequacy, viability, connectivity) and methodologies (self-assessments, matrix approach, spatial assessments) have been developed (OSPAR 2006, Ardron 2008*a*, *b*, OSPAR 2008*b*, Piekainen and Korpinen 2008, Olsen et al. 2013). The Celtic Seas MSFD subregion covers nearly 1 million square km (929,378 km^2) and encompasses 533 MPAs. The overarching aim of this work was to assess the potential of this set of MPAs designated across the waters of three EU Member States in meeting the requirements under OSPAR and the MSFD of being a "coherent and representative" network at the subregional scale of the Celtic Seas, and critically evaluate where the gaps in the network coherence criteria lie. Importantly, while previous work has been undertaken at broader scales, for example, OSPAR regions (Johnson et al. 2014), or narrower scales, for example, national scales (Lieberknecht et al. 2014), the scale of an MSFD subregion is a new scale at which to view networks of MPAs and is increasingly relevant to European marine conservation science as it constitutes the scale at which Member States are required to coordinate national strategies to achieve GES.

Methodology

Study area

The Celtic Seas MSFD subregion (Fig. 1) is delineated by (1) the full EEZ of the Republic of Ireland; (2) the portion of French EEZ assigned as "the Celtic Seas"; and (3) the portion of the UK EEZ currently defined as the "Celtic Seas" for the purposes of the MSFD. The UK MSFD "Celtic Seas" reporting area is in the process of being finalized, but for the purposes of this study, we used the most recent draft proposed area across the UK territorial seas (note that this does not encompass the furthest extent of the UK EEZ, i.e., Hatton Bank and Rockall Bank).

MPA selection criteria

The MPAs in the Celtic Seas region fall into two main types: (1) those designated under European legislation (Birds and Habitats Directives, Special Protection Areas (SPAs), and Special Areas of Conservation (SACs), respectively, that together comprise the Natura 2000 network) and (2) national designations that include Marine Conservation Zones (MCZs, England, Wales, and

Northern Ireland), Nature Conservation MPAs (Scotland), Sites of Special Scientific Interest (UK), Areas of Special Scientific Interest (Northern Ireland), and Parcs Naturels Marins (France). There is considerable variation in the planning processes, conservation objectives, and management between these different designation types.

MPAs encompassed within the Celtic Seas MSFD subregion were included in the analysis if:

1. They were either fully marine or included a marine component (e.g., SACs with marine components were included).
2. They fell within the Celtic Seas study area. MPAs that fell partially within the study area were included but their area was clipped to the boundary (i.e., only the part of the MPA within the study boundaries was included in analyses).

Coastal limits of MPAs were defined by the mean high-water mark, except where MPA boundaries cross the EU Water Framework Directive (WFD) coastal/transitional waters boundary. Transitional waters fall outside of the MSFD reporting remit; so where an MPA's boundary overlapped from coastal to transitional waters, its boundary was clipped to the coastal waters limit, and the transitional waters part was removed from analyses. In addition, a large proportion of MPA sites in the Celtic Seas MSFD subregion has been designated under more than one legal framework; thus, a number of MPA designation types in the network overlap, either fully or partially (e.g., SACs with OSPAR MPAs). Consequently, the actual area covered by MPAs is far less than the sum of all MPA areas. To ensure analyses were not duplicated in overlapping MPAs, and to avoid over-estimating the number of MPAs in which a particular feature occurs, overlapping MPAs were accounted for prior to any analysis (full details provided in Appendix S1). In this assessment, 533 MPAs (or parts thereof) across the Celtic Seas region were considered (Fig. 1).

Data

Full details of data sources and data handling prior to analysis are provided in Appendix S1. Throughout this study, habitats are expressed as MSFD predominant habitat types, following re-classification of habitats listed in MPA documents and databases (see Appendix S1 for full details).

Ecological coherence assessment

Ecological coherence of the Celtic Seas MPA network was assessed using two previously published methods: (1) spatial assessment—examination of the overall network using tests that consider the spatial arrangement and spatial characteristics of the MPA network (OSPAR 2007) and (2) matrix approach—cross-tabulation of habitats reported to be contained within the network, against MPAs (OSPAR 2008*b*). For both methods, a number of criteria defined by OSPAR (2008*b*) were evaluated: representativity, replication, adequacy, viability, and connectivity. Using these criteria, the MPA network was assessed at a coarse scale (spatial distribution and area coverage of MPAs, bathymetric and biogeographic representativity) and fine scale (representativity, replication and area coverage of habitats (adequacy), MPA size (viability), and habitat connectivity). Recommended thresholds against which the network was assessed are provided for each criterion in Appendix S1.

*Spatial analysis.—*Within the spatial analysis, a number of criteria were assessed. Full methodologies for each of these are provided in Appendix S1 describing how the spatial coverage and biogeographic and bathymetric representativity of the network were assessed, along with representativity and replication of habitats, adequacy of habitats, viability of MPAs and habitat patches, and connectivity of habitat patches. Recommended thresholds for each criterion against which the network was assessed are presented in Table 1.

*Matrix approach.—*The matrix approach was used to assess the representativity and replication of habitats within the Celtic Seas MPA network. Matrices were created by tabulating the habitats that occur within the Celtic Seas MSFD subregion, against the MPAs in which they are listed as features (detailed methods are provided in OSPAR 2008*b*). Lists of qualifying habitats (for which the MPA was designated) were extracted from MPA regulation/advice documents. Terrestrial and freshwater habitats were removed; only marine and coastal habitats were included in analyses. Results were organized by country to determine the frequency of occurrence of qualifying habitats

Table 1. Recommended thresholds, and associated reference(s), for each criterion against which the network was assessed.

Criterion	Thresholds applied	References
Spatial coverage	10% of coastal and marine areas	CBD (2010)
Biogeographic representativity	At least 3% of most (7/10) of the relevant Dinter biogeographic provinces in the study area†	OSPAR (2008*a*)
Habitat representativity	Minimum patch size of 0.24 km^2	OSPAR (2013)
Replication	(1) Minimum patch size of 0.24 km^2 and (2) recommended thresholds for replication of habitats within MPA networks have yet to be clearly defined, with suggested values ranging from one replicate of each habitat to five or more. Here, we applied the following thresholds: low (replication of habitat in 0, 1, 2 MPAs), moderate (3, 4, 5 MPAs), and high replication (≥6 MPAs)	Roberts et al. (2003), Jackson et al. (2008), OSPAR (2008*a*), HELCOM (2010)
Adequacy	(1) 20–30% of each habitat (2) Habitat-specific conservation thresholds (detailed in Appendix S1: Table S1)	(1) IUCN (2003), OSPAR (2006) (2) Rondinini (2010)
Viability: MPA size	Recommended size range of 10–100 km^2	Halpern and Warner (2003)
Viability: habitat patch size distribution	Habitat patch size classes: 0–1 km^2 (sessile or very limited mobility species), 1–10 km^2 (species that have low mobility), 10–50 km^2 (species with medium mobility), 50–100 km^2 (species that are highly mobile), and >100 km^2 (species that are very highly mobile)	Roberts et al. (2010)
Connectivity	40 km buffer around MPAs	Natural England and the Joint Nature Conservation Committee (2010)

† In contrast to the other thresholds, the threshold for biogeographic representativity has been set very low as a basic criterion to determine when ecological coherence has *not been met* (OSPAR 2013).

within the Celtic Seas MPA network. Recommended thresholds for each criterion against which the network was assessed are presented in Table 1.

Results

Spatial analysis

*Spatial coverage.—*The Celtic Seas MPA network consists of 533 individual MPAs (or parts of MPAs, in the case of coastal sites), covering an area of 98,411 km^2 (including overlapping MPAs), which corresponds to 274 sites covering an effective area of 91,500 km^2 (excluding overlaps) or 10% of the Celtic Seas study region (Fig. 1). Based on an initial visual inspection of the MPA network map (Fig. 1), it is clear that there is uneven distribution of MPAs between the waters of each of the Member States, with a greater number in Scottish waters and less in Irish waters. Additionally, there is obvious clustering of MPAs in inshore waters, with noticeably less MPAs in offshore waters. On a quantitative level, the Celtic Seas MPA network meets the CBD 10% threshold at the MSFD subregional scale, although the percentage of each nation's waters protected within the boundaries of the Celtic Seas MPA network ranges from 2% for Isle of Man waters to 21% for Scottish waters (Table 2). At the level of Member States, only the UK exceeds the 10% threshold set by the CBD (2010), with 17% of waters within the boundaries of the Celtic Seas MPA network. Ireland and France have just 2% and 6% of their Celtic Sea waters within the boundaries of the Celtic Seas MPA network, respectively.

The majority of MPAs within the Celtic Seas MPA network are located in inshore regions (within 12 nm of the coast; Table 2). The exception to this is Scotland, where 24% of offshore waters occur within MPAs compared to just 10% of inshore waters. This is an order of magnitude higher than the other Celtic Sea states, which have between 0% and 4% of offshore waters within the boundaries of MPAs (Table 2).

*Biogeographic representativity.—*All six Dinter biogeographic provinces that occur within the Celtic Seas MSFD subregion pass the 3% OSPAR (2008*b*) threshold, with between 3.7% and 9.6%

Table 2. Overall area of waters under the national jurisdiction of England, Wales, Scotland, Northern Ireland, Ireland, France, and the Isle of Man and proportions of inshore (12 nm from the shore) and offshore (12–200 nm from the shore) areas within the boundaries of the Celtic Seas MSFD subregion, and area of respective national waters within the Celtic Seas MPA network.

Region	Total number of designated MPAs/ Number of MPAs after overlaps removed	Legal zone within the Celtic Seas	Total area of national waters within Celtic Seas MSFD subregion (km^2)	Area (and %) of national waters within boundaries of the Celtic Seas MPA network (km^2)	Assessment threshold
England and Wales	161/65	Inshore and offshore	128,993	11,754 (9)	–
England	–	Inshore	20,073	3138 (16)	++
Wales	–	Inshore	15,520	5158 (33)	++
England and Wales	–	Offshore	93,401	3458 (4)	–
Scotland	182/95	Inshore and offshore	348,297	71,276 (21)	++
Scotland	–	Inshore	76,581	7418 (10)	++
Scotland	–	Offshore	271,716	63,858 (24)	++
N. Ireland	43/20	Inshore	5242	589 (11)	++
Isle of Man	1/1	Inshore	4622	95 (2)	–
UK	387/181	Inshore and offshore	487,155	83,702 (17)	++
UK	–	Inshore	117,416	16,303 (14)	++
UK	–	Offshore	369,739	67,316 (18)	++
Ireland	143/92	Inshore and offshore	413,813	6084 (2)	–
Ireland	–	Inshore	39,594	3508 (9)	–
Ireland	–	Offshore	374,219	3676 (1)	–
France	3/1	Inshore and offshore	28,410	1703 (6)	–
France	–	Inshore	2327	1703 (73)	++
France	–	Offshore	26,084	0 (0)	–
Total	533	Inshore and offshore	929,378	91,500 (10)	++

Notes: MPA overlaps were taken into account for area and percent calculations. Values meeting threshold of 10% of an area (CBD 2010) are shown as ++, while those below threshold are shown as −.

of each province within MPAs (Table 3). Thus, the Celtic Seas MPA network is covering adequate proportions of the biogeography present in the subregion.

*Bathymetric representativity.—*The bathymetric range of the Celtic Seas MSFD subregion extends from 0.1 to >4000 m and was divided into five depth zones. While each depth zone is represented within the MPA network (Table 3), the distribution of MPAs across the depth zones is uneven, with shallower areas (<75 m) well represented, but just 4.9% and 1.6% of the 75–200 m and >2000 m zones, respectively, represented within the boundaries of the MPA network. This is despite the fact that these two depth zones cover 33.9% and 18.6% of the Celtic Seas subregion, respectively (Table 3). Interestingly, the 200–2000 m depth zone is well represented within the Celtic Seas MPA network.

*Habitat representativity and replication.—*All of the 18 MSFD predominant habitat types found within the Celtic Seas MSFD subregion are represented within the Celtic Seas MPA network. In addition, all of these habitat types are highly replicated based on the thresholds applied (Table 1) and occur in six or more MPAs (Table 4).

*Adequacy.—*Despite good representativity and considerable replication of all MSFD habitats within the Celtic Seas network, less than half of these habitats have >20% of their area within the MPA network (Table 4). Furthermore, three of the 18 MSFD predominant habitat types (shelf sublittoral mixed sediment, shelf sublittoral mud, and shelf sublittoral sand) have less than 10% of their area within the MPA network, despite having a conservable proportion of habitat within the Celtic Seas study area (between 16,000 and 113,000 km^2; Table 4). When the habitat-specific thresholds (Appendix S1: Table S1) calculated by Rondinini (2010) are applied, the results are very similar, with only

Table 3. (A) Areas of biogeographic provinces in the Celtic Seas MSFD subregion and the MPA network; (B) area of each bathymetric zone in the Celtic Seas MSFD subregion and the MPA network.

Biogeographic province	Area within Celtic Seas MSFD subregion (km^2)	Area (and %) within Celtic Seas MPA network (km^2)	Assessment threshold
(A)			
Benthic			
Boreal–Lusitanian	381011.8	25410.0 (6.7)	++
Lusitanian–Boreal	66396.2	4000.6 (6.0)	++
Deep sea	337639.9	32440.3 (9.6)	++
Boreal	142487.7	5278.6 (3.7)	++
Pelagic			
Cool-temperate water	839579.9	63128.9 (7.5)	++
Warm-temperate water	89177.1	4000.6 (4.5)	++
Country	**Total area of depth zone within the Celtic Seas MSFD subregion (km^2)**	**Area (and %) of depth zone within boundaries of the Celtic Seas MPA network (km^2)**	**Assessment threshold**
(B)			
0–10 m (coastal)	12,440	5532 (44.5)	++
10–75 m (shelf seas)	110,657	12,863 (11.6)	++
75–200 m (deeper shelf seas)	315,387	15,511 (4.9)	–
200–2000 m (slope/upper bathyal)	318,189	54,770 (17.2)	++
>2000 m (lower bathyal/abyssal)	172,420	2703 (1.6)	–

Note: (A) Values exceeding the threshold of 3% of the province within the network are shown as ++, while those below the threshold are shown as −; (B) Values meeting the 10% area threshold are shown as ++, while those below the threshold are shown as −.

eight of the 18 habitat types having an adequate proportion of their area within the network (Table 4).

*Viability.—1. MPA size.—*The size of all MPAs within the Celtic Seas network is highly variable and ranges from less than 1 km^2 to more than 23,000 km^2, with the size distribution skewed toward smaller MPAs (Fig. 2). The median size of MPAs in the network is 5.3 km^2, which is only slightly above the global average of 4.6 km^2 (Wood et al. 2008). When thresholds from the literature are applied to the data, 59% of MPAs (316 MPAs) are smaller than 10 km^2, the lower threshold of the recommended size range of 10–100 km^2 (Halpern and Warner 2003). However, 31% of MPAs (165 MPAs) within the network fall within the recommended size range of 10–100 km^2, and 3% of MPAs (18 MPAs) are larger than 1000 km^2 (Fig. 2). Smaller MPAs are clustered in inshore areas, with larger MPAs located offshore (Fig. 1).

*2. Habitat patch size frequency distribution.—*The size distribution of patches of MSFD predominant habitat types was assessed in the Celtic Seas study area and within designated MPAs within the Celtic Seas network. The size distribution of the majority of habitat patches within the MPA network is skewed toward the smaller size classes (0–1 and 1–10 km^2), with 55% of habitat patches smaller than 1 km^2 and an additional 40% in the range 1–10 km^2 (Appendix S1: Fig. S2).

*Connectivity.—*Of the 18 MSFD predominant habitat types, 10 were found to have habitat patches within MPAs that have more than 10 potential connections to habitat patches in adjacent MPAs (Table 5); that is, habitat patches are less than 80 km apart. The remaining eight habitats have between two and seven potential connections (Table 5). Higher potential connectivity of habitat patches was observed in shallow sublittoral and littoral habitats, with lower potential connectivity observed among patches of deep-sea habitats.

Matrix approach

*MSFD predominant habitats.—*All 18 MSFD predominant habitat types within the Celtic Seas MSFD subregion were listed as features in the conservation objectives of between 1 (shallow sublittoral mud/shelf sublittoral mud) and 144

Table 4. Representativity, replication, and adequacy of MSFD predominant habitat types within the Celtic Seas MPA network.

MSFD predominant seabed habitat type	EUNIS level 3-associated habitats	Total area of habitat in Celtic Seas study area (km²)	Area of habitat in MPAs (km²)	Number of MPAs habitat occurs in	Proportion of habitat in MPAs (%)	Habitat-specific threshold (%)/Threshold met?
Abyssal rock and biogenic reef; Lower bathyal rock and biogenic reef; Upper bathyal rock and biogenic reef	A6.1; A6.2; A6.6; A6.7; A6.8	32251.6	13752.6	13 ++	42.6 ++	12.1/Yes
Abyssal sediment; Lower bathyal sediment; Upper bathyal sediment	A6.3; A6.4; A6.5; A6.9	287430.1	47912.2	20 ++	16.7 −	12.1/Yes
Littoral rock and biogenic reef	A1.1; A1.2; A1.3; A1.4; A2.7	85.3	39.4	24 ++	46.2 ++	41.8/Yes
Littoral sediment	A2.1; A2.2; A2.3; A2.6; A2.8	630.0	620.1	46 ++	98.4 ++	41.8/Yes
Shallow sublittoral coarse sediment	A5.1; A5.5	49139.6	10674.0	100 ++	21.7 ++	32.5/No
Shallow sublittoral mixed sediment	A5.4; A5.5	5313.6	971.8	49 ++	18.3 −	32.0/No
Shallow sublittoral mud	A5.3; A5.5	8248.6	1500.4	51 ++	18.2 −	29.9/No
Shallow sublittoral rock and biogenic reef	A3.1; A3.2; A3.3; A3.7; A4.1; A4.2; A4.7; A5.5; A5.6	37842.1	7702.9	158 ++	20.4 ++	32.4/No
Shallow sublittoral sand	A5.2; A5.5	36432.1	5949.9	118 ++	16.3 −	30.0/No
Shelf sublittoral coarse sediment	A5.15	70491.2	12079.9	33 ++	17.1 −	32.5/No
Shelf sublittoral mixed sediment	A5.45	16702.5	891.5	11 ++	5.3 −	32.0/No
Shelf sublittoral mud	A5.37	26808.3	798.7	12 ++	3.0 −	29.9/No
Shelf sublittoral rock and biogenic reef	A4.1; A4.2; A5.6	27962.7	4479.2	107 ++	16.0 −	28.0/No
Shelf sublittoral sand	A5.27	113379.6	9079.8	26 ++	8.0 −	30.0/No

Notes: Habitat patches present within overlapping MPAs were only recorded once. All habitats were highly replicated (present in ≥6 MPAs) and are shown as ++. For adequacy, a 20% threshold was applied across all habitat types with thresholds met shown as ++ and those not met shown as −, in addition to habitat-specific thresholds (Appendix S1: Table S1). In some instances, it was not possible to distinguish between upper bathyal, lower bathyal, and abyssal habitat types when converting from EUNIS classification to MSFD habitat type; thus, some habitat types are grouped.

(littoral sediment) MPAs (Table 6). All habitat types, except shallow sublittoral mud/shelf sublittoral mud, meet the high replication threshold and are listed within the conservation objectives of more than six MPAs within the Celtic Seas network (Table 6).

Discussion

Achieving ecological coherence relies on the network of MPA sites meeting a number of different criteria; thus, it is often much easier to demonstrate that a network is not ecologically coherent than to provide evidence to support its ecological coherence (OSPAR 2007, HELCOM 2010). Furthermore, ecological coherence assessments are also often limited by the use of broadscale habitat data (see Appendix S1). While these data are currently the "best available evidence" (OSPAR 2013), there is potential for mis-representation of ecologically relevant habitat and important ecological details can be unintentionally overlooked due to mismatches of scale and the limited criteria used to create broadscale habitat classifications (Williams et al. 2009, Olsen et al. 2013). Unless moves are made to underpin such coarse-scale analysis with finer-scale analysis methods during assessments of ecological coherence, such issues will persist. However, the data do not currently exist for such fine-scale analyses at the scale of ecological coherence assessments, which typically extend over regional, national, and international boundaries.

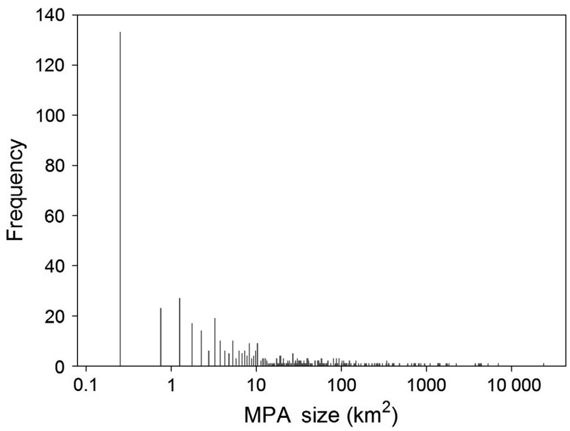

Fig. 2. Size distribution of all 533 MPAs within the Celtic Seas MPA network (*x*-axis is a log10 scale).

Nevertheless, until such data are available, coarse-scale ecological coherence assessments, as demonstrated here, can provide useful information on where further effort can be targeted to progress toward ecological coherence, as is the case for the Celtic Seas MPA network. While the MPA network in its current state does not achieve ecological coherence (according to our current understanding and accepted thresholds, Table 1), a number of positive aspects of the network were revealed (Table 7) and areas identified where improvements can be made.

Spatial coverage, bathymetric representativity, and MPA size distribution of the MPA network

The Celtic Seas MPA network exceeds the spatial coverage threshold set by the CBD to designate 10% of coastal and marine waters as MPAs. However, Ireland and France fail to meet this 10% target in their Celtic Seas waters. It could be argued that this point is irrelevant given that the Celtic Seas MPA network as a whole meets the target. However, Ireland's entire EEZ is in the Celtic Seas subregion, and only 2% of their waters are protected; this represents a clear failure to meet CBD targets at both a national and subregional level. Furthermore, some could argue that failing to take into account the contributions of all nations within regional and subregional assessments could allow some nations to evade their responsibility to meet MPA targets, while other nations are left to shoulder the responsibility. The issue in French waters is one of uneven distribution, as overall 12% of its waters are within the Natura 2000 network (EEA 2015), and when national sites are included, this figure is likely to be higher, but protection is not spread evenly throughout the four MSFD subregions that France's waters fall within, and the Celtic Seas subregion (which represents 7% of France's waters) is underrepresented. However, it is important to note that clustering of MPAs in inshore waters is expected as habitat heterogeneity, survey effort (in relation to data collection), and marine resource use are typically greater in these areas than further offshore (Vincent 2011, Lieberknecht et al. 2014). If both Ireland and France improved MPA coverage in their Celtic Seas waters, this would further boost the Celtic Seas MPA network.

There is an obvious clustering of MPA designations in inshore areas, and there is an evident lack of MPAs in all offshore regions, aside from Scottish offshore waters. Further MPAs were recommended in English and Welsh offshore waters but the designation process was stalled for several years due to political and economic issues (Defra 2015*a*); however, a second tranche of 23 MCZs was announced for designation in January 2016, including three offshore sites in the South West

Table 5. Number of potential connections between patches of the same MSFD predominant habitat type within MPAs in the Celtic Seas network.

Number of potential connections between habitat patches	MSFD habitat types with this number of connections
2	Shelf sublittoral mixed sediment
3	Abyssal rock and biogenic reef; Lower bathyal rock and biogenic reef; Upper bathyal rock and biogenic reef
5	Abyssal sediment; Shelf sublittoral mud
6	Upper bathyal sediment
7	Lower bathyal sediment
>10	Littoral rock and biogenic reef; Shallow sublittoral coarse sediment; Shallow sublittoral mixed sediment; Shallow sublittoral mud; Shelf sublittoral sand
>15	Littoral sediment; Shelf sublittoral coarse sediment
>20	Shallow sublittoral rock and biogenic reef; Shallow sublittoral sand; Shelf sublittoral rock and biogenic reef

Table 6. Number of MPAs in which MSFD predominant habitat types are listed as conservation objectives in the Celtic Seas network (upscaled from EUNIS Level 3 data).

MSFD predominant habitat type	No. MPAs in England, Scotland, and Wales	No. MPAs in Northern Ireland	No. MPAs in France	No. MPAs in Ireland	No. MPAs in Offshore	Total No. MPAs
Littoral rock and biogenic reef	49	10	1	39	9	108 ++
Littoral sediment	60	12	1	62	9	144 ++
Shallow sublittoral coarse sediment; Shallow sublittoral sand; Shallow sublittoral mud; Shallow sublittoral mixed sediment	18	5	1	2		26 ++
Shallow sublittoral coarse sediment; Shelf sublittoral coarse sediment	18	5	1	2	1	27 ++
Shallow sublittoral mixed sediment; Shelf sublittoral mixed sediment	6					6 ++
Shallow sublittoral mud; Shelf sublittoral mud	1					1 −
Shallow sublittoral rock and biogenic reef	44	4	1	37	10	96 ++
Shallow sublittoral rock and biogenic reef; Shelf sublittoral rock and biogenic reef	44	4	1	37	11	97 ++
Shallow sublittoral sand; Shelf sublittoral sand	21	5	1	2	1	30 ++
Upper bathyal rock and biogenic reef; Lower bathyal rock and biogenic reef; Abyssal rock and biogenic reef	2	1	1	5	8	17 ++
Upper bathyal sediment; Lower bathyal sediment; Abyssal sediment	0				6	6 ++

Notes: Values represent minimum occurrence where MPA overlaps are accounted for. Habitats with a low (0, 1, 2) number of replicates are shown as −, those with a moderate (3, 4, 5) number of replicates are shown as +, and those with a high (≥6) number of replicates are shown as ++. In some instances, it was not possible to distinguish between upper bathyal, lower bathyal, and abyssal habitat types when converting from EUNIS classification to MSFD habitat type; thus, some habitat types are grouped. No. denotes number.

UK, which cover an area of 4119 km^2 in the Celtic Seas region. Five offshore sites adjacent to Welsh inshore waters were removed from consideration in the second tranche of MCZ sites and are no longer being considered since the Silk Commission on Welsh devolution recommended that marine conservation in the offshore area adjacent to Wales should be devolved to Welsh government (Silk Commission 2012). In addition, a further three sites protecting mud seabed habitat (plus Celtic Deep, one of the sites adjacent to Welsh waters) were removed from consideration because of perceived impacts on the *Nephrops* fishery sector, particularly in Northern Ireland. If the political and economic barriers for the additional seven offshore sites were to be resolved, coverage in offshore waters of England and Wales would increase by 2996 and 274 km^2, respectively (Celtic Deep falls into both categories, but has been only included in the first). If the three tranche 2 offshore MCZ sites, sites stalled by political processes (adjacent to Welsh waters), and sites stalled through economic interests were all to be designated (a total of 7389 km^2), it would increase MPA area coverage to 12% in English and Welsh offshore waters, exceeding the CBD target of 10%, and the offshore region would no longer constitute a gap.

By contrast, to date there has been no parallel designation process of national MPAs in Ireland's waters (which represent 45% of the Celtic Seas region) to join up their European Marine Sites and OSPAR MPAs into a coherent MPA network (required by MSFD, Article 13(4)). This has relevance to the achievement of GES targets given the focal role of MPAs as a measure to support the delivery of GES in UK, French, and Irish waters, particularly for Descriptors 1 (biodiversity) and 6

Table 7. Summary of the main conclusions of the ecological coherence assessment of the Celtic Seas MPA network.

Analysis method	Criteria	Feature	Results	Assessment threshold
Spatial analysis	Representativity	Spatial coverage	10% of Celtic Seas study area is within MPA network	++
Spatial analysis	Representativity	Spatial coverage	14% of Celtic Seas inshore region (within 12 nm) is within the MPA network	++
Spatial analysis	Representativity	Spatial coverage	9% of the Celtic Seas offshore region (beyond 12 nm) is within the MPA network	−
Spatial analysis	Representativity	Biogeography	Over 3% of each of the dominant biogeographic benthic and pelagic provinces is included within the Celtic Seas MPA network	++
Spatial analysis	Representativity	Bathymetry	Representativity of coastal (0–10 m), shelf seas (10–75 m), and slope/upper bathyal (200–2000 m) areas within the MPA network is good. Deeper shelf seas (75–200 m) and lower bathyal/abyssal (>2000 m) areas are less well represented within the network	+
Spatial analysis	Representativity	MSFD predominant habitat	All MSFD predominant habitat types are represented in the MPA network	++
Spatial analysis	Replication	MSFD predominant habitat	All MSFD predominant habitat types are well replicated in the MPA network	++
Spatial analysis	Adequacy	MSFD predominant habitat	Less than half of the MSFD predominant habitats (7 of 18) have an adequate proportion (>20%) of their area within the MPA network, and less than half of the MSFD predominant habitats (8 of 18) meet the habitat-specific thresholds	−
Spatial analysis	Viability	Size of MPA	The size of MPAs within the Celtic Seas network is highly variable and ranges from less than 1-km^2 to more than 23,000-km^2 MPA. Over half the MPAs within the Celtic Seas network may be too small to sustain populations of species with a variety of dispersal and migratory patterns, though may be suitable for specific purposes, for example, breeding bird colonies	+
Spatial analysis	Viability	MSFD predominant habitat patch size frequency distribution	The size distribution of the majority of MSFD habitat patches is skewed toward the smaller size classes (0–1 and 1–10 km^2), suggesting that the MPA network is only likely to support low- to medium-mobility species	+
Spatial analysis	Connectivity	MSFD predominant habitat	There are higher potential connectivity of shallow sublittoral and littoral habitat types and lower potential connectivity of deep-sea habitats	+
Matrix approach	Representativity	MSFD predominant habitat	All MSFD predominant habitat types are represented in the Celtic Seas MPA network	++
Matrix approach	Replication	MSFD predominant habitat	All MSFD predominant habitat types, except shallow sublittoral mud/shelf sublittoral mud, meet the threshold for replication	+

Note: Positive results are shown as ++, intermediate results shown as +, and gaps in the network shown as −.

(seafloor integrity; MEDDE 2014, DECLG 2015, Defra 2015*b*). There is, however, an intention by the Irish government to develop a national strategy for the creation and management of Ireland's network of MPAs as part of the programme of measures (DECLG 2015); thus, this gap has been recognized and may be filled in the future.

As a consequence of a lack of offshore MPAs, representativity of MPAs across depth zones in the Celtic Seas MPA network is also uneven, with greater representativity of shallower areas. However, the 200–2000 m depth zone is well represented within the network due to the high number of offshore MPAs in Scottish waters. Uneven spatial distribution of MPAs is common at both the global and regional scale (Foster et al. 2014, Johnson et al. 2014, Lieberknecht et al. 2014), with the majority of MPAs typically located in coastal and nearshore waters, and just 1.79% and 0.17% of off-shelf waters and high seas, respectively, occurring within MPAs (Spalding et al. 2013). While the Celtic Seas MPA network in its current state does not fall within accepted thresholds of ecological coherence, additional MPAs in offshore and deeper shelf seas areas, in all but Scottish waters, would greatly improve the spatial distribution of the network. However, care should be exercised in the establishment of MPAs in more remote areas to ensure that these MPAs are not "residual," that is, being designated in areas with minimal anthropogenic impacts/human activities and without changes in management, essentially not increasing protection to support biodiversity conservation (Devillers et al. 2015). In addition to contributing to area targets, sites should also protect habitats and species most exposed to damaging activities, such as fishing and deep-sea mining (Devillers et al. 2015).

The size of MPAs within a network is important, and MPA size within the Celtic Seas MPA network was found to be highly variable, with more than half of MPAs smaller than the recommended 10–100 km^2 threshold (Halpern and Warner 2003). These results suggest that at least half of the MPAs within the Celtic Seas network may be too small to sustain populations of species with a variety of dispersal and migratory patterns. However, it is important to note that many smaller MPAs have been designated for specific purposes, such as protecting breeding bird colonies, and do not necessarily need to be of a large size. Furthermore, research has shown that small MPAs (<10 km in their minimum dimension) that are well managed can provide good protection to many species, and should be included within MPA networks (Roberts et al. 2010). However, larger MPAs provide better protection than small MPAs (Roberts et al. 2010). A third of MPAs within the Celtic Seas MPA network fall within the recommended size range of 10–100 km^2 suggested by Halpern and Warner (2003) and 18 MPAs are larger than 1000 km^2, suggesting that they have the potential to support highly mobile species and self-sustaining populations (Hill et al. 2010). However, additional medium (10–100 km^2)- and large (>1000 km^2)-sized MPAs would further enhance the network in respect of area coverage and supporting the integrity of populations and communities.

While MPA size is important, the spacing of MPAs and the connectivity of similar habitats within MPAs is also a fundamental element of any network (Roberts et al. 2010). With this in mind, the potential connectivity of patches of MSFD predominant habitat types within the Celtic Seas MPA network was also assessed by identifying patches of habitat within MPAs that were no more than 80 km apart. More than half of the habitat types were found to have high potential connectivity to neighboring habitats within the network. These habitats were typically within the shallow sublittoral and littoral regions of the network, where the number of MPAs is generally higher and the spacing of MPAs is closer. For habitats located in the deep sea and on the shelf, potential connectivity was lower, adding further support to a requirement for an increase in the number of offshore MPAs, particularly in deeper waters, to enhance the ecological coherence of the Celtic Seas MPA network. However, it is important to remember that the 40 km buffer has limited ecological relevance and was selected to allow comparisons to previous studies. Assessing the connectivity of habitats and species within the Celtic Seas MPA network requires a much more in-depth study taking into account individual biological traits.

At present, the Celtic Seas MPA network is skewed toward small MPAs and the conservation of small habitat patches. This configuration supports low to limited mobility species. Further analysis of the qualifying features within MPAs and MPA size is required to determine whether larger MPAs would be beneficial in the Celtic Seas region. Viability could also be enhanced by an in-depth study to determine how the MPA network currently supports more mobile species during essential life history stages (e.g., breeding). The connectivity of the Celtic Seas MPA network should also be reconsidered by undertaking a more detailed analysis of larval dispersal distances and oceanographic features (e.g., currents). As a minimum, the potential connectivity of offshore and deep-sea habitats should be enhanced by designating further offshore MPAs.

Representativity, replication, and adequacy of habitats within the MPA network

Given that gaps were identified in the Celtic Seas MPA network using the coarse-scale criteria, it was expected that the fine-scale criteria would reveal further gaps, and this was most evident during the assessment of adequacy. Assessing the representativity, replication, and adequacy of habitats within a MPA network is often challenging due to the limited availability of comprehensive spatial data on the distribution of habitats. This is exacerbated further when assessing networks that span large geographic areas, offshore regions, and are transboundary in nature, such as the Celtic Seas MSFD subregion. The current analysis relied heavily on modeled habitat maps (EUSeaMap), and while these are a useful amalgamation of many disparate datasets into a single readily interpretable product (OSPAR 2013), care must be taken when interpreting the results. Small fragments of habitat can be generated by chance when input data are scarce or lacking due to the low predictive power of such models (Piekainen and Korpinen 2008, HELCOM 2010, OSPAR 2013). In the current study, habitat patches smaller than 0.24 km^2 were removed prior to analysis, based on the minimum patch size set by Piekainen and Korpinen (2008) in HELCOM (2010). While this limited the likelihood that biologically insignificant habitat fragments were included in the analysis, patches of less common habitats may have been overlooked. Given that less common habitats require a greater proportion of protection than widely distributed habitats (Johnson et al. 2014), improved data coverage of habitat distribution is crucial to ensure assessments of ecological coherence are as comprehensive as possible.

Nevertheless, based on the available data for the Celtic Seas subregion, MSFD predominant habitat types were found to be represented and highly replicated within the MPA network. While these results indicate good coverage of MSFD habitats by the Celtic Seas MPA network, it is important to remember that the Celtic Seas subregion includes six distinct Dinter biogeographic provinces, and OSPAR (2006) recommend analyses be undertaken at the scale of biogeographic provinces in order to capture differences resulting from biogeographical drivers. Unfortunately, limited data availability prevented analyses at the scale of biogeographic provinces in the current study. However, if the analyses were to be repeated at the scale of provinces within the Celtic Seas subregion, representativity and replication of habitats would likely be reduced, resulting in the network being further from achieving ecological coherence.

While there are good representativity and high replication of MSFD predominant habitat types within the Celtic Seas network as a whole, the results of the adequacy analysis are not so favorable. The analyses for representativity and replication look solely at the presence/absence of a habitat within the network and do not consider the area of the habitat being assessed. While it is important to have good representation and replication of habitats within an MPA network, the area of the habitat included within the network must also be of a suitable size to ensure the ecological viability and integrity of populations, species, and communities (Rondinini 2010). The criterion of adequacy provides additional information on ecological coherence by assessing the total area of each habitat occurring within the network, with targets set as the percentage of habitat required in MPAs to ensure the long-term viability of habitats and associated species. A number of thresholds have been developed and we applied a flat-across-the-board 20% target (IUCN 2003, OSPAR 2006) in addition to habitat-specific targets developed by Rondinini (2010) (Appendix S1: Table S1). Under both of these targets, less than half of the MSFD predominant habitat types met the associated threshold recommended to protect the integrity and ecological functions of the populations and communities within the habitats. Larger areas and proportions of habitat are generally recommended over smaller areas as these typically support a greater number of species and their movements and are, thus, more likely to provide a greater number of ecological functions, be more resilient to change, and be able to recover from disturbance (MacArthur and Wilson 1967, Roberts et al. 2010). An assessment of the spatial distribution of habitats in relation to MPA location would help to identify possible MPAs that could be extended to incorporate larger areas of habitats, in addition to the designation of new sites. Furthermore, the majority of habitats with very small areas within MPAs are shelf and deep-sea habitats; thus, designation of offshore MPAs would also contribute to the proportion of these habitats occurring within the MPA network and increase progress toward adequacy thresholds and overall ecological coherence of the network.

Moreover, the size frequency distribution of the majority of MSFD predominant habitat patches was skewed toward smaller size classes (<10 km^2), suggesting that only low- to medium-mobility species are supported by the MPA network. In general, habitat patches in the larger size classes (>50 km^2), which are likely to support more mobile species, are only observed in deep-sea habitats, such as bathyal and abyssal sediments, rock, and biogenic reef. Thus, to move the Celtic Seas MPA network toward ecological coherence, a significant increase in the patch size and area coverage of habitats within MPAs is required for both shallow and deep habitat types, to ensure the protection of viable populations of the full range of species.

Matrix approach

In general, results of the matrix approach supported results from the spatial analysis, indicating that MSFD predominant habitat types are well represented and well replicated within the Celtic Seas MPA network. However, differences were observed between the results of the two methods. Littoral habitats showed significantly higher replication in the matrix approach than in the spatial approach. This is likely due to methods employed during spatial analyses, where patches <0.24 km^2 were removed from the analysis, ambiguous habitat descriptions in EUSeaMap for MPAs in Ireland had to be discarded, data were not available for large areas around Ireland (e.g., 30 MPAs where littoral sediment is listed as a feature do not have data to support spatial analysis), and MPAs were clipped to the WFD coastal waters; thus, habitats beyond this area were not included in the spatial analysis. For some habitats, the opposite effect was observed, with higher replication in the spatial analysis than in the matrix approach. Again, this is likely to be attributable to artefacts in the methods. For the matrix approach, habitat information was taken directly from MPA documents, where habitats are usually listed as broadscale categories, for example, EUNIS Level 3 habitats or Annex 1 habitats, and these were then upscaled to MSFD predominant habitat types for analysis. However, in the spatial analysis, fine-scale habitat data were used in addition to broadscale data, resulting in more habitat types upscaled to MSFD habitat types and hence higher replication values.

Conclusions

Even though the Celtic Seas MPA network meets the desired CBD 10% spatial coverage for MPAs, it must be noted that there are still significant gaps in the network as assessed against the principles of ecological coherence; at a global scale, biodiversity continues to decline for some marine habitats and indicator species (Butchart et al. 2010, Pimm et al. 2014, WWF 2015), and is predicted to continue to decline due to the persistent pressures on marine ecosystems exerted by patterns of consumption, pollution, invasive species, and climate change (Butchart et al. 2010, Tittensor et al. 2014). There is a need to integrate the broader thresholds for ecological coherence into MPA network design in an attempt to underpin biodiversity conservation and the associated well-being benefits. The MSFD is a key European driver for creating a coherent and representative network of MPAs at a European level, which will protect the marine natural resource base upon which social and economic activities depend. MPAs are crucial components of the programme of measures to achieve GES, and in particular for achieving targets set for biodiversity and seafloor integrity, but to achieve ecologically coherent networks of MPAs that deliver these targets requires assessments at a regional and subregional scale and cooperation between Member State governments to coordinate MPA designations.

This study represents the first assessment of the ecological coherence of an MPA network at a subregional scale to inform the development of marine strategies to support delivery of GES under the MSFD. This study demonstrates a methodology and approach that could be replicated in other MSFD regions and subregions. The results of this study raise four key challenges that need to be addressed at the European level. Firstly, there are large disparities between Member States with regard to making national progress toward MPA designation. There is a need to initiate progress toward this goal, particularly with regard to the designation of MPAs that are adequate and viable. Secondly, the MSFD subregions are large geographic areas, including offshore regions, and are transboundary in nature. At a European level, there is a need to facilitate progress toward transboundary agreements and coordination of MPA designation processes to protect and connect marine biodiversity in shared marine areas. Thirdly, limited availability of empirical data on the distribution of habitats and species across broad geographic areas restricts the types of analyses that can be undertaken. Improved data collection, data sharing, and consistent use of terminology by all Member States needs to be instigated to ensure ecological coherence assessments accurately reflect reality. Finally, there is a need to establish protocols at a European level for assessing the management effectiveness of MPAs. By addressing these key challenges, MPA networks would be enhanced at the European scale, enabling them to fulfill their critical role in the delivery of GES. However, the UK's move out of the EU imposes some level of uncertainty surrounding nature conservation in the UK and the applicability of certain directives, including the MSFD and regional approaches to meeting its targets. If the UK were to completely leave the EU's internal market, the MSFD would remain in place but there would be no pressure or enforcement from the EU to ensure targets are met (IEEP 2016). This could prove challenging in relation to regional approaches, such as the Celtic Seas, with EU Member States bound by the directive's targets (France and Ireland), while the UK would not have to deliver on the same targets. However, if the UK were to become part of the European Economic Area (EEA), then it would remain bound by the MSFD's targets, but would have no influence on future developments of the MSFD (IEEP 2016). Given the lengthy negotiation process that lies ahead between the UK and the EU, it is difficult to say with certainty what the impacts will be on future nature conservation in the UK.

Acknowledgments

The authors are grateful to all organizations that made their data on habitat and species distribution available for inclusion in the analysis. This was an EC Life+ funded project. The authors declare that there are no conflicts of interest.

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